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ISSUED BY THE  
LAKE STATES FOREST  
EXPERIMENT STATION

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## SEED GERMINATION TECHNIQUE

The Station is carrying on a large program of seed testing in connection with both the Shelterbelt project and the Region Nine planting program. A number of inquiries have been received as to the details of this work, so the technique is outlined here.

As seed is received from the field it is stored in a 50° F, cold room. When work is started on the sample, it is removed to the laboratory and given a serial test number.

It is of particular importance in the field that the samples made up for submission for germination tests should be a true representation of the seed to be tested. It is of equal importance that an accurate sample of the lot submitted for test should be obtained in the laboratory. To insure this, the seeds are passed through a "seed sampling machine" which divides the seeds into two parts, approximately equal in number and, as far as possible, equal with respect to variability. The sample submitted is divided with the machine until approximately 1,000 seeds are obtained. This sample, including all chaff, seeds of other species, and other impurities which are incorporated in the lot, is then weighed to the nearest miligram. The seed is counted, separated from the chaff and impurities and the clean seed weighed. From these figures it is possible to compute the number of seed per pound in a standard sample and the number of seed per pound of clean seed.

After the sorting and counting, the original sample is divided into five sub-samples of 200 seeds each with the sampling machine. These smaller lots are placed in bottles or vials and carefully labeled. They are then returned to the cold room to await sowing for germination.

When the sample is ready for germination, 100 seeds are chosen from the original samples submitted by the sender, for a "cutting test." This is to approximate the percentage of good, and blind seed; and for old seed, the endosperm is examined to see if it is fresh and white or yellow and rancid.

For the actual germination test a fine sand is used. It is previously sterilized in a kiln at about 100°C. for 2 to 4 days. Each flat is filled to within about one-quarter inch from the top, depending upon the diameter of the seed to be planted. Seeds are planted to sufficient depth so that they will be covered to about twice their thickness. After the seeds have been sown and pressed into the sand, they are covered with sand and the surface leveled off with a board.

Four samples of 200 seeds each is sown in a flat. Each sample is segregated in one corner and a strip of about an inch in width is left between the samples to avoid confusion. The five sub-samples of each 1,000 seed sample are sown in five different flats. Where possible, adjacent space in the flat may be sown to seeds of different species. This is done only when the seeds will all germinate in approximately the same time. A slow germinating seed is not placed in the same flat as a promptly germinating seed. Opposite each seed sample in the flat is tacked a tag, embossed with the complete serial test number and proper sub-sample identification.

After the seeds are sown, the flat is weighed and sufficient moisture is added to bring the sand in the flat up to 8% moisture content. This moisture content is maintained throughout the test. Distilled water only is used for rinsing and watering the plants.

The flats are then placed on germination tables. Two rooms are available. One is kept at a temperature of 40° (night) to 60° (day) F. and in it are placed those seeds which require lower temperatures for germination such as Juniperus species. The other room ranges from 60° to 80° F. This covers the optimum temperatures for most of the seeds under test. Over each table are suspended three 200-watt lights for illumination. Automatic equipment regulates both temperature and illumination.

Seedlings are pulled, as soon as they have germinated. A seedling is counted as germinated as soon as the green loop of the hypocotyl appears above the sand level. Accurate records of the daily progress of germination are kept and the test is continued until practically all seeds have germinated that will ever do so. This varies with the species from one to two months and even longer for some seeds.

A word should be added concerning the seeds of those species which require some special pre-treatments. For stratifying, a series of cold rooms with temperatures of -6°, 2°, 5° and 10° and 18° C. are available. Sulfuric acid, hot water and other chemical tests are performed in the laboratory. The Station is also equipped with a scarifier. All seeds are sown promptly upon the completion of the pre-treatments.

#### FORESTS AND CIRCULATION OF WATER

On March 22, Mr. Zon delivered an address at the Mayo Foundation chapter of Sigma Xi. His subject was "The Role of the Forests in the Circulation of Water on the Earth's Surface." This subject is very definitely related to shelterbelts, soil erosion work and conservation activities in general. A brief summary of the address is given here.

The part which forests play in the circulation of water on the earth's surface is not yet fully understood. There are many meteorologists and engineers who deny altogether the effect of forests on the amount and distribution of rainfall. The old theory that the source of all our precipitation over the continent is evaporation from the surfaces of our oceans is still prevalent. According to this theory, the vapor from the oceans is carried by the wind to the continent, there condensed in the form of rain or snow, and later returned through rivers back to the ocean.

Bruckner's investigations on the circulation of water in the atmosphere dealt a serious blow to this theory, and threw in bold relief the evaporation from the earth's surface itself as the most important source of our precipitation. According to his calculations, the oceans contribute only two-ninths of the entire precipitation that takes place over the land areas draining towards the oceans. Seven-ninths of the precipitation over the earth is derived from evaporation from the land itself.

Studies of the loss of water from the different earth coverings show that free surfaces of lakes and streams contribute less vapor to the air than bare moist soils. Land covered with grass or crops contributes through direct evaporation and through transpiration more vapor to the air than bare moist soils. Of all the vegetative coverings, a dense forest contributes most vapor.

## SOIL TEMPERATURE AFFECTS GERMINATION AND DEVELOPMENT OF WHITE PINE SEEDLINGS

A recent bulletin from the Vermont Agricultural Experiment Station\* stresses the importance of soil temperature as a factor in the germination and early growth of white pine seedlings. That the lack of reproduction under dense stands is the direct result of unfavorable soil temperature rather than deficiency in soil moisture or light is the premise advanced in this study.

The work was carried out in a greenhouse in order that all factors except soil temperature would be constant for all the plants under observation. Soil moisture per cent was kept constant in all cases. Seedlings were grown in zinc cans which were placed in water baths maintained at constant temperatures. Four different temperatures were used. There was some range in the soil temperatures in each can both at the same depth and at different depths. However, the temperatures were maintained satisfactorily from a practical standpoint. The average temperatures used were: Series I, 51.5°F; Series II 59.7°F; Series III, 67.2°F; and Series IV, 88.1°F. The highest germination per cent and the shortest germination period were observed in the cans having the highest temperature, but many of these seedlings failed to survive during the summer. The best germination and survival was found in Series III.

As for the development of the seedlings, those in Series IV, the warmest, had very much better tops than the others. Those grown in the coldest soil were poorly developed, being still succulent at the end of the first year, whereas all the others were woody. The roots showed even more striking differences. The roots of the plants grown in the cold soil were more filaments of very short length. The plants grown in the warmest soil had the most extensive root system. The lengths of the main root as well as the total length of all lateral roots of the plants in Series IV were much greater than in the other soils. This was especially so in the case of the lateral roots which showed an increase of 212 per cent over the next lower temperature.

It appears then that soil temperature is a very important factor in the reproduction of white pine and very probably in other species as well. The soil temperature is largely dependent on direct insolation as expressed by light intensity. When the crowns of the trees form a dense canopy the soil below them is apt to be quite cold during the spring and early summer. This inhibits germination and growth and probably by the time the soil temperature has become favorable, some other factor, very likely soil moisture, has become unfavorable. Even if the seeds are able to germinate under a dense canopy, the seedlings usually fail to develop and harden, a failure which is attributable to low light intensity and resultant low soil temperatures.

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\*W. R. Adams, "Studies in Tolerance of New England Forest Trees - XI The Influence of Soil Temperature on the Germination and Development of White Pine Seedlings." Vermont Agricultural Experiment Station, Burlington, Vermont.

## GIRDLING OF NORTHERN HARDWOODS

The physiological effects of girdling are of great help in determining the effectiveness of different methods of doing this work. Henry I. Baldwin has presented the results of a careful study of this subject in a recent article.\* Three different methods were used and a number of seasons were tried out for this work. However, late winter is so definitely superior from the standpoint of cheapness and organization of the work that the author felt it unnecessary to present data except for work done in February and March. (The Station has found that girdling in the early summer is most effective in reducing sprouting - see Forest Research Digest for February 1935) The three methods used were: (a) notching, which consists in making a clean notch all the way around the tree; (b) peeling, which is stripping the bark on a belt six inches to a foot wide around the tree; (c) hacking, which is done by making a series of downward cuts through the bark. The last method is cheapest but unreliable since strands of conductive tissue are often left uncut. This method should not be used.

During the first season following girdling no great change is noticed in the cut trees until fall. The girdled trees then show autumnal coloration from two to four weeks in advance of control trees. A few of the trees had died by September but most showed no effect except the earlier coloring. Girdled trees equalled the controls in abundance of seed.

In the second season many trees were decidedly lower in vigor, leaves developed poorly, they were smaller on the average and many of them dropped soon after they had opened. Autumnal coloration was again in advance of control trees. The more sensitive species were nearly all dead by the end of the season. These species were: black ash, black cherry, beech, and paper birch.

It was noticed that the trees which were easier to cut into were the first to die. The soft wooded, intolerant species afforded the easiest chopping and these died first.

Analyses were made of moisture content and sugar content above and below the cut on girdled trees and also on comparable uncut trees. At the end of the first year, it was found that sugar content above the cut varied from 20 to 300 times as great as that below, and from 2 to 3 times that in control trees of the same species. This excess of sugar above the cut is caused by the interruption of the downward passage of carbohydrates which occurs chiefly in the phloem which lies just under the bark. Notching was found to be more effective than peeling in causing this accumulation of sugars above the cut. At the end of the second year the reserves of sugar were greatly depleted and were even less above the cut than in the control trees.

Moisture content of the wood was more variable and not enough data was available to determine definitely and completely what the effect of girdling is on this factor, although it was usually lower in girdled trees than in the controls.

In summarizing it may be said that girdling is an effective method of eliminating the competition of undesirable hardwoods. The notching method, while slightly more costly, yields surer results than the others.

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\*Baldwin, Henry I. - "Some Physiological Effects of Girdling Northern Hardwoods." Bulletin of the Torrey Botanical Club 61:249-257. 1 May, 1934.



## THE GROWTH RATE OF NATURAL STANDS

The timber survey of the Kawishiwi Experimental Forest on the Superior National Forest throws some light on the rate of growth of the common timber types in that region. The following table shows the net volume growth in cords per acre per year for 65-year-old even-aged stands.

Type	Basis (Acres)	Volume per Acre in Cords <u>1/</u> (Trees 5.5" D.B.H. & over)	Mean Annual Growth in Cords (for 65 yrs.)
Jack Pine	953	13.6	.21
Aspen	439	12.3	.19
Mixed (conifer, aspen birch)	343	8.8	.14
Black spruce (upland)	152	7.8	.12
Black spruce (productive swamp)	421	4.4	.07

1/ Cordwood volume of 6" and 7" trees computed directly.  
Volume of trees over 7" computed in board feet and converted with the ratio 400 board feet equals 1 cord.

The growth rates shown here are naturally much lower than those shown in normal yield tables because many of the stands are understocked and there have been serious natural losses due to the larch sawfly, spruce budworm, porcupine, wind, and other destructive agencies. The 1932 storm reduced the volume of the stand between 15 and 20 per cent.

Like Patrick Henry, foresters must judge the future by the past, and the above values must represent what this tract can be expected to yield until the stocking has been increased or growth conditions improved.

## CULTIVATION OF PLANTATIONS

The Southern Forest Experiment Station<sup>\*</sup> has found that cultivation of young black locust plantations has a very beneficial effect on their growth and development. Two furrows were plowed on each side of a row or else the ground was broken by a hoe for a distance of about 18 inches around each tree. The cultivated trees had about four times as much leaf area and consequently they grew considerably more in height than the checks. The terminal shoots of the cultivated trees averaged 12.7 inches in length compared to an average of 3.1 inches for the uncultivated trees. In addition to greater height growths the cultivated trees have well formed crowns with vigorous lateral branches which are in marked contrast to the slender stems and crowns of the uncultivated trees.

\* Southern Forestry Notes No. 9, issued by Southern Forest Experiment Station.

## BARK BEETLES AND BLUE STAIN

Results of a study of the interrelationships of bark beetles and the fungus which produces blue-stains in logs and lumber are presented in the August 15, 1934\* issue of the Journal of Agricultural Research. The field work was carried on at the Lake Itasca Forest Biology Station in Minnesota, using Norway pine logs.

Freshly felled sound logs of Norway pine were treated in various ways, then put out in the open under lattices which afforded about 50% shade. The entrance of bark beetles was prevented in some of the logs by covering them with screens and in these logs no blue-stain developed except in one case, where a beetle had managed to get through the screen, and in this case the blue-stain was definitely restricted to the locality of the tunnels made by the beetle. Evidence obtained by careful examination of the beetles showed very plainly that blue-stain spores are carried by the bark beetles both externally and internally. The beetles under consideration are *Ips pini* and *Ips grandicollis*. Several other fungi and some yeasts are also frequently found associated with these beetles but the spores of the blue-stain fungus were found in every beetle examined. The experiment shows conclusively that blue stain is introduced into the logs by the bark beetle.

## RESEARCH AND ACQUISITION

The report to the National Forest Reservation Commission recommending the acquisition of 260,000 acres in North Dakota was largely based on information gained by experiments carried out at the North Dakota branch station of the Lake States Forest Experiment Station. This branch has developed planting methods which have been successful even in the difficult conditions of the past few years, and this fact was instrumental in securing the approval of the Commission.

## THE SOIL AS A GUIDE TO STAND TREATMENT

The considerable attention now being paid by foresters to land acquisition, planting and the various methods of building up our depleted forest resources brings out the need for information on the basic relationships between forests and soils. Recent studies made by the Station in connection with the Forest Surveys in Michigan, Wisconsin, and Minnesota show forest composition and site index to be quite closely correlated with soil texture.

Although the results of these studies are not entirely conclusive, they are believed to give a good indication of the natural cover relationships and productivity to be expected on the soils of the Northern Lake States. The soils of the region have been divided into groups on the basis of texture. These groups have real significance in that they suggest the extent and the character of silvicultural treatment justifiable. A summary of the groups is given in the following table.

A number of copies of a more detailed article embodying the results of these studies are available at the Station and may be obtained on request.

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\*(The Interrelationships of Bark Beetles and Blue-Staining Fungi in Felled Norway Pine Timber, by J. G. Leach, L. W. Orr, and Clyde Christensen, Journal of Agricultural Research, August 15, 1934).

# DISTINGUISHING CHARACTERISTICS OF THE MAJOR SOIL GROUPS OF THE LAKE STATES REGION

Soil Group	Topographic Features	Texture	Forest Cover	Vegetation	General Recommendations
Poor sandy soils	Occurs on level outwash plains or sandy moraines.	Deep sands or gravelly sands, coarse to medium in texture; drainage excessive.	Poorly-stocked stands of scrubby jack pine and oak.	Sweet fern, sand cherry, huckleberry, blueberry, bearberry, sedge, beard grass, and others.	The poor quality and slow growth of timber produced here does not justify intensive management. Planting will be of doubtful success. Natural stands should be given fire protection but otherwise left alone.
Better sand plains	Level outwash plains.	Sands of generally finer texture than soils of above group; water table often at lesser depth; moisture conditions hence more favorable.	Well-stocked stands of thrifty jack pine, often with reproduction of Norway pine and white pine.	Much the same as in preceding group but is of better individual development.	Well adapted for production of jack pine and Norway pine timber. White pine and dry-site oak may be used in certain places. Planting, thinnings and release cuttings may prove profitable here.
Sandy loams	Hilly upland such as crests and slopes of ridges; some times as level plains, narrow valleys and bench land.	Sands, loamy sands, or sandy loams underlain by sandy to clayey loams which are often gravelly and stony; drainage good to rapid.	Dominantly aspen and paper birch; in southern Michigan second-growth oaks. A large area has some reproduction of conifers and hardwoods.	Largely a mixture of some species from the preceding groups and others from the following group.	Great possibilities as forest land since growth is good. Open areas may be planted to white pine; the aspen stands may either be converted to stands of the more valuable hardwoods and conifers (where these are already present) or grown for cordwood.



DISTINGUISHING CHARACTERISTICS OF THE MAJOR SOIL GROUPS OF THE LAKE STATES REGION (Con't).

Soil Group	Topographic Features	Texture	Forest Cover	Vegetation	General Recommendations
Loams	Rolling plains and broad ridge tops and slopes of ridges.	Loams and fine sandy loams or heavy loams or sandy clays; often stony; drainage good.	Largely aspen and paper birch, usually with an understory of the better hardwoods and conifers.	Wild leek, wild spikenard, blue cohosh, hepatica, bloodroot, trillium; maidenhair fern, and others	Where no conflict with agriculture, these soils should be used for growing hardwoods or white spruce. Aspen conversion to hardwoods or conifers highly practicable because of the large amount of reproduction. In certain places aspen may be grown for box lumber or cordwood.
Heavy loams	Found chiefly on till plains or on glacial lake beds.	Loams, silt loams, or clay loams underlain by heavy, impervious clay which is often limy; soils relatively stonefree; drainage slow.	Chiefly aspen with an understory of the better conifers and hardwoods.	Wild ginger, chanter's nightshade, horsetail, red osier, sweet coltsfoot, skunk curreant and highbush cranberry.	Same as for preceding group except that white spruce should perhaps be favored over hardwoods in any silvicultural treatment of the stands.
Poorly drained mineral soils	Occurs on wet plains or in narrow strips along edge of swamps, lakes, and rivers.	Black mineral soil, high in organic matter, over water logged sand or heavy wet clay; soil at times very wet.	Dense stands of elm, black ash, red maple, balsam-of-Gilead, cedar, spruce, balsam, yellow birch, and aspen, in varying mixtures.	Nettles, marsh marigold, Joe-Pye weed, sensitive fern, goldenglow, alder, and jewelweed.	These soils are very productive and should be used for the production of swamp conifers wherever these species are present. Cultural work applied to the natural mixtures will probably yield satisfying results.

DISTINGUISHING CHARACTERISTICS OF THE MAJOR SOIL GROUPS OF THE LAKE STATES REGION (Con't).

Soil Group	Topographic features	Texture	Forest Cover	Vegetation	General Recommendations
		Black, finely-divided, well-decomposed, peats or mucks; slightly acid to alkaline in reaction	Dense stands of elm, black ash, red maple, and balsam-of-Gilead often mixed with such conifers as cedar and balsam	Much the same as in preceding group.	Since these are the most productive swamps, the natural mixtures should be maintained. Improvement cuttings, release cuttings, and possibly thinnings may be justifiable.
Poorly drained organic soils.	Occurs in the form of deep bogs occupying old lakes and depressions, or shallow swamps in valleys and rolling plains.	Reddish-brown to black, moderately decomposed peat, finely fibrous to granular in texture; moderately to slightly acid.	Medium to well-stocked stands of white cedar or black spruce and tamarack. The trees are of good form and thrifty appearance.	Cedar swamps-- creeping snow-berry, goldthread twin flower, bunchberry, wood sorrel, and various mosses. Black spruce-- tamarack swamps-- most of the species from the next group of which Labrador tea and sphagnum moss are dominant.	The relatively slow growth here does not justify any intensive cultural work. Improvement cuttings may be desirable in some places.
		Yellow, coarsely fibrous, poorly decomposed peat; strongly acid in reaction.	Open stands of stunted black spruce and tamarack with crooked, broom-like crowns, or a dense cover of bog shrubs and sphagnum moss with scattered groups of small spruce.	Leatherleaf, Labrador tea, sphagnum moss, cranberry, swamp laurel, pitcher plant, blueberry and bog rosemary	Due to the very slow growth in these non-productive swamps no cultural work of any kind should be attempted. Of greater value for game cover and water storage than for timber production.